ORDER

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

6950.27

10/3/94

SUBJ: SHORT CIRCUIT ANALYSIS AND PROTECTIVE DEVICE COORDINATION STUDY

1. PURPOSE. This order directs the accomplishment of short circuit analysis and protective device coordination studies for facility power systems. These power engineering studies are necessary to minimize unscheduled facility outages caused by unanticipated operation of protective devices. Failure of improperly applied power protective devices are a safety hazard to installation and maintenance personnel. Application of uncoordinated protective devices also degrades the reliability and availability of facility power systems.

2. DISTRIBUTION. This order is distributed to division level within the Program Manager for Advanced Automation, Program Directors for Automation, Communication and Aircraft Acquisition, Navigation and Landing, Surveillance, Weather and Flight Service Systems, NAS Operations, Operational Support, Requirements and Life-Cycle Management, NAS Transition and Implementation, and Facility System Engineering Service; to office level at the Aeronautical Center; to the division level in Engineering, Test, and Evaluation Service at the FAA Technical Center; to the division level in the regional Airway Facilities divisions; and to all Airway Facilities field offices with standard distribution.

3. BACKGROUND. The National Electrical Code, 240-12, Fine Print Note (FPN) states in part: "Coordination is defined as properly localizing a fault condition to restrict outages to equipment affected, accomplished by choice of selective fault protective devices." The lack of a proper short circuit and coordination study can place a facility in serious risk of a major shutdown. This has been illustrated by a major facility/service interruption that occurred at a level V airport traffic control tower/terminal radar approach control facility (ATCT/TRACON). This interruption occurred during the installation of electronic equipment connected to the critical electrical power distribution system. The equipment involved had a factory wiring error. When energized, it caused a series of events resulting in the tripping of several circuit breakers, including the main protection of the critical power system. If these devices had been properly coordinated, only the equipment's branch circuit protective device would have opened. This outage had a major impact on the air traffic control system due to the loss of the entire terminal control area.

4. IMPLEMENTATION.

a. A short circuit analysis and protective device coordination study of the facility power distribution system shall be accomplished in accordance with the National Electrical Code and FAA standard, FAA-STD-032, Design Standards for

National Airspace System Physical Facilities, prior to construction of new facilities or major equipment additions or modifications to existing facilities. This shall be accomplished:

(1) As part of the initial design package.

(2) Whenever existing facilities are undergoing major modifications to the facility power system (i.e., installation of uninterruptible power supply (UPS), installation or replacement of engine-generator, refurbishment of facility power distribution system, replacement of service transformer, etc.)

(3) Whenever major electronic/electrical equipment installations are accomplished.

b. These studies should be accomplished on existing facilities not meeting the criterion above as resources permit. The goal is to have a power distribution system serving National Airspace System (NAS) facilities that is properly rated and will provide selective fault isolation.

5. RESPONSIBILITIES.

a. All Project Implementation Plans (PIP) shall incorporate the requirement to perform a short circuit and coordination study. Accomplishment of this requirement will be a joint responsibility of the regional facilities and equipment (F&E) staffs and appropriate program offices. The Engineering and Environmental Safety Division, ANS-500, will have oversight responsibility on this effort.

b. Only qualified engineers shall do a short circuit and coordination study of the power distribution system they design as part of their service. The study shall be used as the basis for specifying the rating and selecting the type of protective devices. To ensure that this requirement is met, the statement of work (SOW) shall include a power system study. A recommended SOW for this purpose is included in Appendix 1, Recommended Statement of Work for Power System Study.

c. Deficiencies identified as a result of the study on existing facilities will be corrected under the project being designed. If they are of such magnitude that implementation of necessary corrective measures can not be funded, they will become the basis of future facility upgrades under CIP 46-07, Power Systems Sustained Support.

6. DELIVERABLES. The study shall be a part of the design data summary handbook in accordance with FAA-STD-032. A copy of the study will be provided to the installation contractor. If changes or deviations from the approved design are made, the installation contractor shall revise affected portions of the study to reflect those changes or deviations. Installation contract specifications shall require the contractor to prepare and submit those revised portions of the study. Additionally, the contract specifications shall require the contractor to submit, as a minimum, one hard copy and one computer diskette (soft copy) in the current FAA-approved format.

7. SUBSYSTEMS AND EQUIPMENT. Protective devices within the equipment or subsystems and the interface to the facility power distribution system shall also be coordinated. This requirement is incorporated in the last edition of Specification FAA-G-2100, General Specification for Ground Based Electronic Equipment. This requirement shall be accomplished by appropriate program offices and coordinated with regional engineers.

8. BASELINED DOCUMENTATION. The study shall become a part of Section IV of the Facility Reference Data File (FRDF). If the power distribution system is changed in any way the baselined study shall be updated. This includes any branch or feeder breaker replacement.

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APPENDIX 1. RECOMMENDED STATEMENT OF WORK (SOW) POWER SYSTEM STUDY

GENERAL.

The performance and reliability of an electrical power system can change significantly as electrical loads increase, as the characteristics of loads change, or as the power supplier's system changes. These changes may result in components being applied beyond their ratings and/or no longer providing protection to equipment and the system. The goal is to have a power distribution system serving NAS facilities that is properly rated and will provide selective fault isolation.

This SOW is designed to obtain engineering studies that identify these problems and recommends solutions.

The design of the electrical power distribution shall include a complete power system study in accordance with FAA-STD-032, Design Standards for National Airspace System Physical Facilities. The study shall include short circuit analysis, protective device coordination, voltage drop analysis, and sizing of stand-by diesel engine-generator and utility service.

SHORT CIRCUIT AND PROTECTIVE DEVICE COORDINATION STUDY.

1. GENERAL REQUIREMENTS.

1.1 The purpose and intent of this study are to:

a. Determine if protective equipment and components are applied within their nameplate ratings.

b. Determine settings needed on adjustable protective devices to protect system components and maximize system availability.

c. Identify changes that are necessary for proper application and protection.

1.2 Whether the study is by contract or consultant it shall be conducted by an engineer with 3 or more years experience on this type of study. Electrical engineering design experience in large hospitals, life safety systems, and/or large computer and telecommunications facilities are preferred. The engineer shall be available to share opinions related to significant recommendations. The engineer shall have proven computer programs for making single-phase and three-phase fault duty calculations. A listing of previous study jobs completed and resume of the engineer shall be available for review. A previous study report shall be available for review to illustrate the type of report that will be supplied.

APPENDIX 1. RECOMMENDED STATEMENT OF WORK (SOW) POWER SYSTEM STUDY CONTINUED

1.3 The study work shall be conducted under the applicable standards of the American National Standards Institute (ANSI), Institute of Electrical and Electronic Engineers (IEEE), and the National Electric Code (NEC). Specifically the following standards shall apply:

a. IEEE C37.010-1979, IEEE Standard Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (includes Supplement C37.010d) (ANSI).

b. IEEE C37.13-1981, IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures (ANSI).

c. IEEE C37.5-1979, IEEE Guide for Calculation of Fault Currents for Application of AC High-Voltage Circuit Breakers Rated on a Total Current Basis (ANSI).

d. IEEE Std 141-1986, IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (ANSI).

e. IEEE Std 242-1986, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (ANSI).

1.4 The basic scope of the study is the facility power system from the power supplier's primary service through the main secondary distribution system up to the branch circuit protective devices.

1.5 For existing facilities, the engineer shall visit the site to become familiar with and obtain data of all components, devices, and equipment in the system.

WORK ELEMENTS.

2. SINGLE-LINE DIAGRAMS.

2.1 The engineer shall prepare a single-line diagram of the power system. This diagram shall identify all components considered in the study and the ratings of all power devices. This includes, but is not limited to, transformers, circuit breakers, relays, fuses, busses, and cables. Reference numbers shall be used on the diagram related to key items in the report. ANSI device function numbers shall be used on protective relays.

3. SHORT CIRCUIT STUDY.

3.1 A short circuit study shall be performed which shows the momentary and interrupting fault duties on each bus shown on the single-line diagram. A computer shall be used to perform calculations on all three-phase faults. In addition, an impedance listing shall be prepared showing bus-to-bus impedance values reduced to a common MVA base referenced to a single-line diagram for ease in reviewing data.

APPENDIX 1. RECOMMENDED STATEMENT OF WORK (SOW) POWER SYSTEM STUDY CONTINUED

3.2 Study each fault interrupting device related to the calculated duty and recommend changes when appropriate.

4. COORDINATION STUDY.

4.1 The engineer shall perform a comprehensive protective device coordination study covering all devices identified on the single-line diagram. The goal is to have a power distribution system serving NAS facilities that is properly rated and will provide selective fault isolation. Provide settings for all adjustable protective devices on a diagram acceptable to the FAA.

4.2 Study the application of devices versus system needs and recommend new or additional devices that are needed for adequate protection.

4.3 Prepare time/current coordination curves to illustrate the protection and coordination achieved with the recommended settings of protective devices. These curves shall reflect the following (where applicable):

a. Appropriate NEC protection points.

b. Appropriate ANSI protection points.

c. Magnetizing inrush points of transformers.

d. One-line diagram of the system identifying the device plotted.

e. Short circuit current levels used for coordination.

f. Through-fault protection curves for liquid immersed transformers.

5.0 Reporting

5.1 The engineer shall submit three bound copies of a report which shall contain the following information:

a. An executive summary which identifies all significant problems and all recommendations for new equipments of significant equipment changes.

b. A tabulation of all protective devices identified on the one-line diagram with their ratings compared with respective fault duty as calculated in the study.

c. A tabulation of the settings recommended on all adjustable protective devices with references to the single-line diagram and to coordination curves.

d. Copies of all time/current coordination curves developed in the study.

APPENDIX 1. RECOMMENDED STATEMENT OF WORK (SOW) POWER SYSTEM STUDY CONTINUED

e. The analysis of problems that lead to specific recommendations included in the executive summary.

f. The single-line diagram of the system studied, including all ratings, identifications described.

g. Copies of all computer results referenced to the single-line diagram and the impedance listings.

The report shall be completed and submitted to FAA within a mutually agreed time. A copy of the approved report shall be included as part of the Design Data Handbook in accordance with FAA-STD-032.